Abu Dhabi National Oil Co.

ADNOC Technical Institute

أدنـــوك
ADNOC
شركة بترول ابوظبي الوطنية

INSTRUMENTATION

INSTRUMENTATION III

UNIT 1

CONVERTERS AND POSITIONERS

UNITS IN THIS COURSE

UNIT 1 CONVERTERS AND POSITIONERS

UNIT 2 RECORDERS

UNIT 3 INDICATORS AND COMBINED UNITS

UNIT 4 HAZARDOUS AREAS AND INTRINSIC SAFETY

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1.0 COURSE OBJECTIVE

The student will be able to:

- Explain the need for I/P and P/I converters.
- Explain the operation of a typical I/P converter e.g. Foxboro.
- Explain the purpose of a positioner.
- Explain the operation of a typical valve positioner e.g. Fisher.
- Explain the operation of a modern combined electrical/pneumatic converter/positioner, e.g. Fisher, Rosemount.
- Explain the operation of typical pneumatic signal to electrical signal converters, e.g. Rosemount, Foxboro.

1.1 INTRODUCTION

The aim of this unit is to explain:

- The operation and use of equipment which converts electrical signals to pneumatic signals (I/P)
- The valve positioner and its uses
- The combined valve positioner and I/P.
- The pneumatic signal to electrical signal converter (P/I).

1.2 THE ELECTRICAL TO PNEUMATIC SIGNAL CONVERTER (I/P)

1.2.1 Introduction

The electrical to pneumatic signal converter (I/P) is an important piece of pneumatic equipment. This is because, even with modern digital transmission systems, most control is done with pneumatically operated valves. The I/P is therefore an essential item in any electrical/electronic control system.

The basic mode of operation is the "electric motor principle". A current passed through a conductor in a magnetic field will make the conductor move. The most common type of I/P which is used a lot in the field is the Foxboro (E69F).

1.2.2 The Foxboro I/P Converter (E69F)

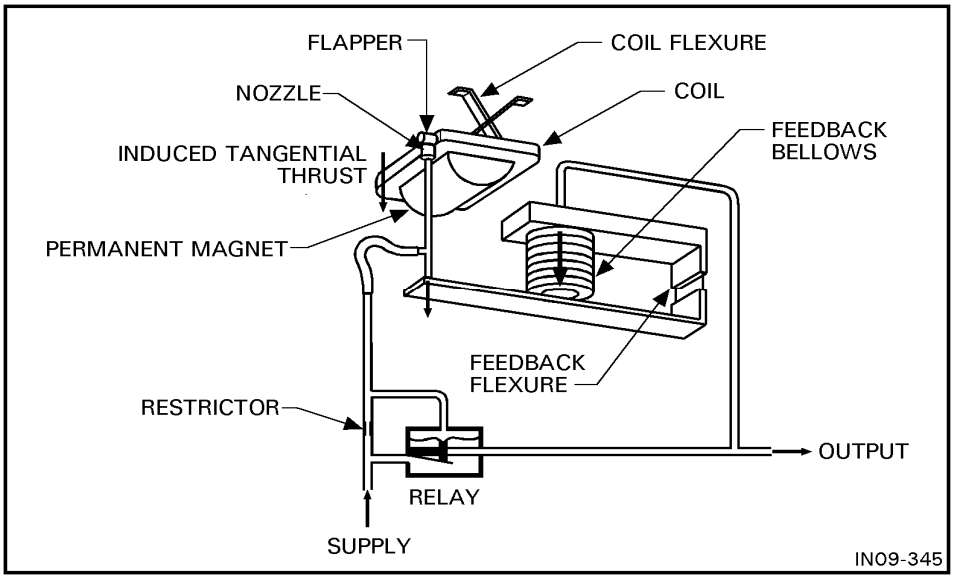
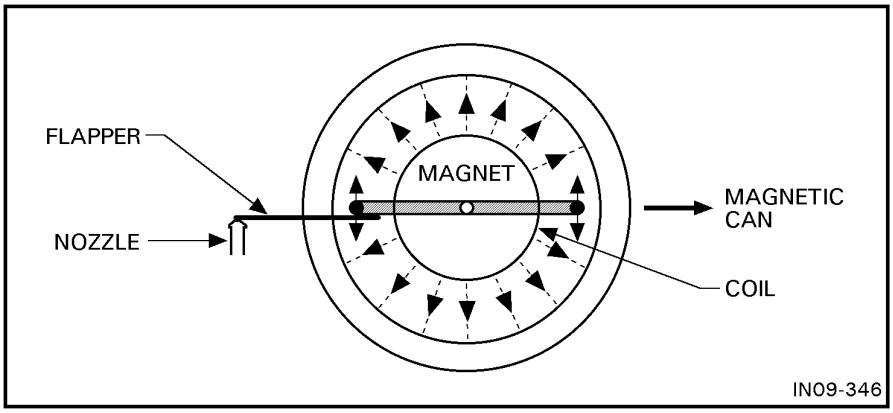


Figure 1-1 The Foxboro I/P Converter

Figure 1-1 shows a schematic diagram of the Foxboro I/P converter. The coil, permanent magnet and coil flexure are mounted inside a can made of magnetic material, e.g. soft iron. The can is not shown in the diagram to make it easier to see. The can makes the magnetic field produced by the permanent magnet run at right angles to the coil. This makes a system similar to a moving coil meter, as shown in the sketch below.



Basic Operation:

An increase in the input current through the coil makes the coil rotate. This moves the flapper towards the nozzle. The back pressure is increased. The change is amplified by the relay and applied to the feedback bellows. This makes the nozzle move away from the flapper until it reaches a new balance position.

The system is arranged so that when the coil current reaches the upper range value (e.g. 20 mA), the pneumatic output signal reaches its own upper range value (e.g. 1 bar). The signal can be adjusted a little by moving the nozzle radially at an angle to the axis of the coil.

Note:- The coil flexure acts as the restoring spring. With minimum current through the coil (e.g. 4 mA), the flexure returns the coil to its starting position and sets a minimum output pressure (e.g. 0.2 bar).

1.3 THE VALVE POSITIONER (DIAPHRAGM ACTUATORS)

A valve positioner is a device fitted onto a control valve to make the valve respond better. It's very good when long pneumatic control signal lines are used.

It will position a valve accurately even if there are unbalanced forces in the valve body. It will also overcome stem friction. However, the positioner provides positive feedback to make the valve respond more quickly. Therefore, it can not be used on modern electronic controls systems as it will cause instability.

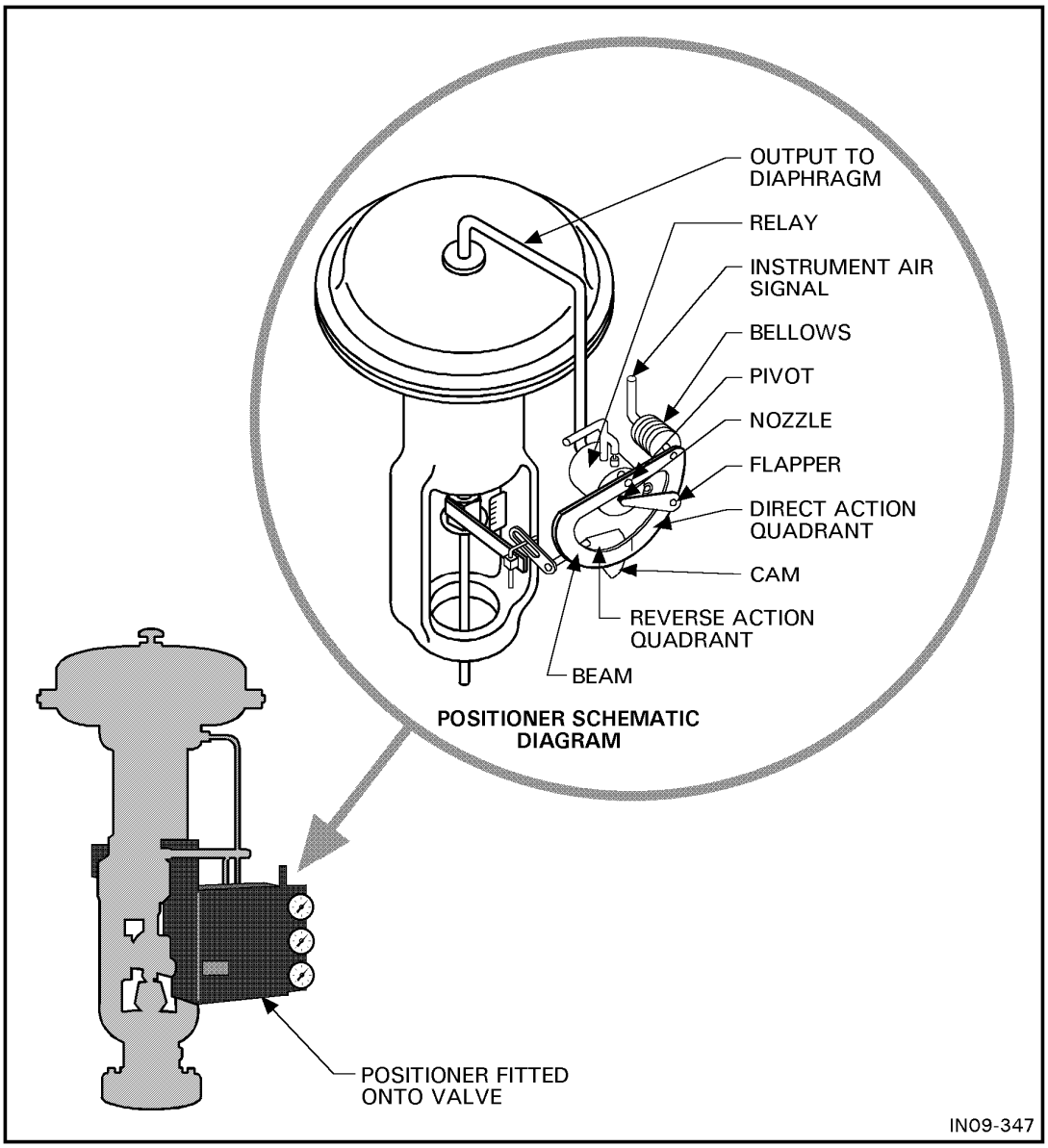


Figure 1-2 The Fisher Valve Positioner

Figure 1-2 shows a typical valve positioner (Fisher) fitted to a control valve. It has an "air to push down" actuator. The schematic diagram shows the main parts of the positioner. This schematic diagram is used to show the operation as follows.

When the instrument pressure increases, the bellows expands and moves the beam. The flapper pivots on the beam and restricts the nozzle. The nozzle pressure increases and moves the relay diaphragm assembly. This

opens the relay supply valve which moves the actuator stem downward. The stem movement is fed back to the beam by means of a cam. This causes the flapper to pivot slightly away from the nozzle. Nozzle pressure decreases and the relay supply valve closes to stop the output pressure from increasing more. The positioner is now in balance again but at a higher instrument pressure. It also has a slightly different flapper position and a new actuator stem position.

When the instrument pressure decreases, the bellows contracts (helped by an internal range spring). This moves the beam to pivot the flapper slightly further from the nozzle. The nozzle pressure decreases and through relay operation, the exhaust valve in the relay opens. This releases the diaphragm actuator pressure to atmosphere, which allows the actuator stem to move upward. This stem movement is fed back to the beam by the cam to reposition the beam and flapper. When everything is in balance again, the exhaust valve closes to stop the pressure in the diaphragm case from falling any more.

The speed of operation depends on how much feedback is applied by the feedback bellows. This can be adjusted by moving the position of the flapper on the quadrant. If the action of the actuator is "air to push up", the positioner must work in the reverse direction. This is done by placing the flapper in the reverse action quadrant of the beam.

1.4 THE VALVE POSITIONER (PISTON ACTUATORS)

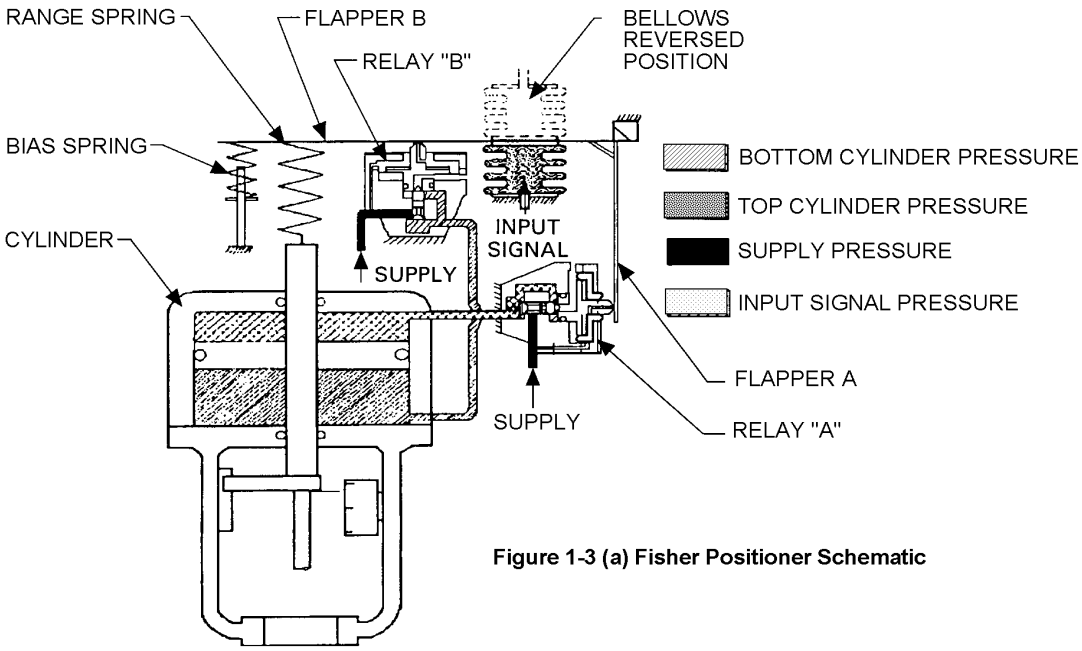


Figure 1-3 (a) Fisher Positioner Schematic

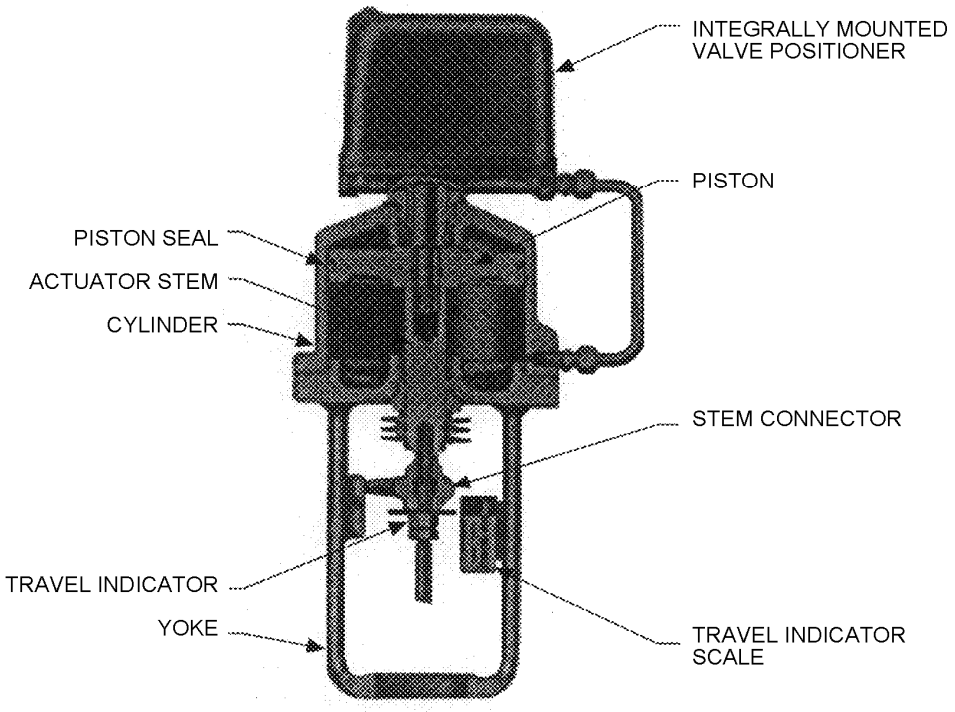


Figure 1-3 (b) The Fisher Positioner Fitted to Piston Actuator

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Figure 1-3 The Fisher Positioner for Piston Actuators

Figure 1-3 shows a Fisher valve positioner for piston actuators. Figure 1-3(a) shows a diagram of the layout of the positioner. Figure 1-3(b) shows the positioner fitted to the piston actuator.

OPERATION

1) The input signal is applied to a bellows. This bellows applies a force to a double flapper assembly which moves using the flexure as a pivot.
2) If the input signal increases, flapper "B", moves away from relay "B" and flapper "A" moves nearer to relay "A". The signal pressure from relay "A" increases and the signal pressure from relay B" decreases.
3) The higher pressure on the top of the piston (relay A) moves the piston down. Therefore the stem moves down to close the valve.
4) The range spring provides the feedback to the system so that the valve is repositioned at the new input controlled position.
5) If the input signal decreases the opposite action occurs. The piston moves up to open the valve at the new input controlled position.
6) The bias spring is adjusted to give the fully open position. This is the "Zero" adjustment where a 3 psi (0.2 bar) input sets the valve fully open.
7) The "span" is set by the range spring. This is selected to give a fully closed valve with a 5 psi (1.0 Bar) input signal.
8) The positioner is easily changed to provide reverse action (input signal 3 psi fully closed) by changing the position of the input signal bellows (as shown).

Note:

The above operation assumes the valve body is direct acting (stem moving down closes the valve).

If the valve requires a reverse action, place the input bellows on the opposite side of the lever as shown.

There are many different types of this positioner/actuator. The type used depends on the length of stroke of the valve and the operating pressures required. The manual must be consulted if the actuator/positioner is not of the standard type described.

1.5 THE COMBINED I/P AND POSITIONER

1.5.1 The Fisher Electro-Pneumatic Positioner

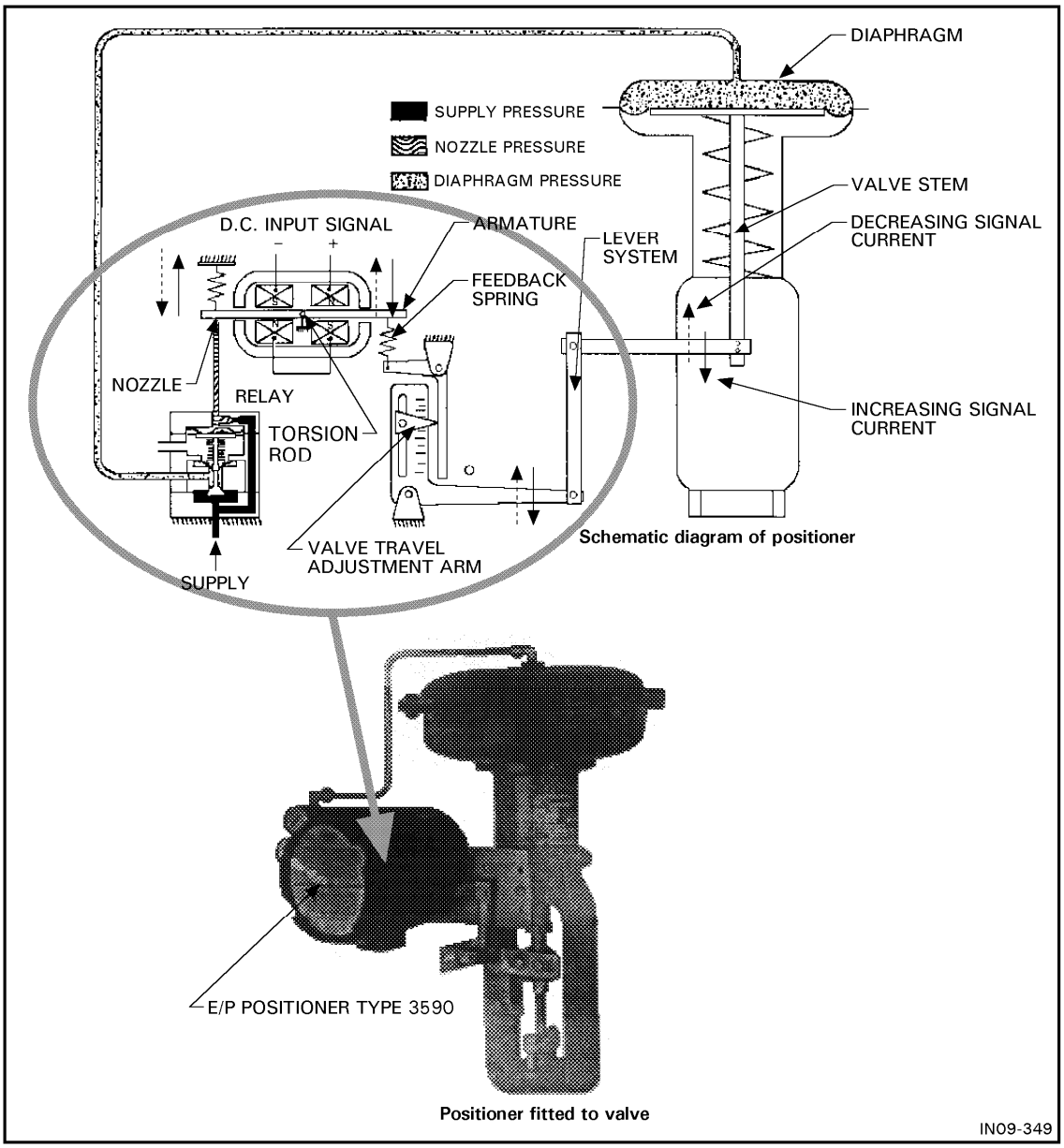


Figure 1-4 The "Fisher" Electro-Pneumatic Valve Positioner

Figure 1-4 shows the Fisher combination I/P and positioner.

OPERATION

- The electric current is changed to pneumatic pressure using a 4 coil system and a magnetic armature.
- The current passing through the coils produces a magnetic field as shown. The armature is pulled up by the positive connection coils and pushed down by the negative connection coils.
- The armature acts as a flapper against the nozzle. A high signal current pushes the flapper nearer to the nozzle and produces a high output signal.
- The relay amplifies the nozzle output and applies it to the diaphragm to move the valve stem.
- Feedback is provided by the lever system.

The solid arrows show the movement as the diaphragm pressure increases. The feedback spring pulls the armature down. The supply current pulls it up. These two opposing forces stabilise the system as the signal current gets higher. If the signal current falls the action is reversed. This is shown by the dotted arrows.

Note:

1) The current to pneumatic conversion unit (torque motor) must never be taken to pieces. If you do this, you cannot set it up again, as the magnetic circuit is ruined.
2) The setting up of this unit is complicated and will be done in the workshop using the manuals.
3) The torsion rod acts like the controlling spring in a moving coil meter. When the signal current is removed the torsion rod puts the armature back to its horizontal position.

1.5.2 Foxboro I/P Valve Positioner (E69P)

The Foxboro I/P valve positioner (type E69P) is an adaptation of the standard I/P described in section 1. Figure 1-5 shows the layout of the system.

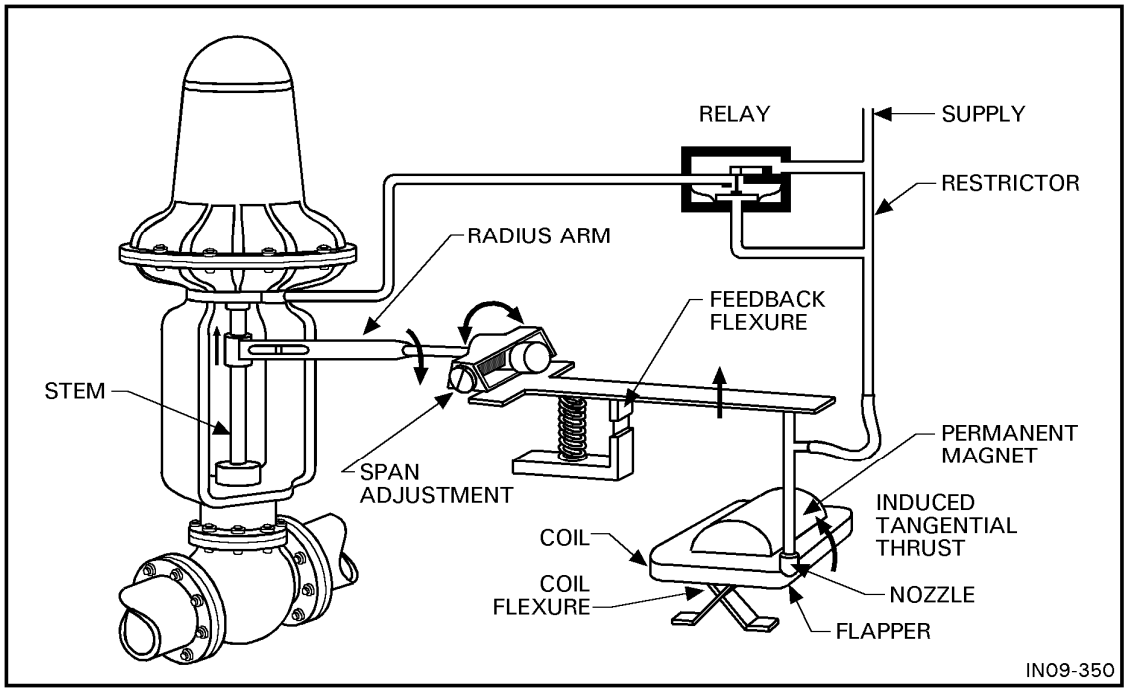


Figure 1-5 Foxboro I/P Valve Positioner

OPERATION

- An increase in current through the coil rotates the flapper closer to the nozzle. The output pressure from the relay goes up.
- The increase in output pressure moves the valve stem up.
- The radius arm connected to the valve stem moves the lever which is pivoted about the feedback flexure. This makes the nozzle move away from the flapper. This provides the feedback required to reposition the valve at its new setting. The span adjustment sets the amount of feedback and thus the size of the stroke.

1.6 PRESSURE TO CURRENT CONVERTERS (P/I)

1.6.1 Introduction

The pressure to current converter (P/I) is the opposite of the current to pressure converter (I/P). It changes an input pressure signal (eg. 3-15 psi) to a standard electrical signal (eg. 4-20mA). The two examples given in the notes are the Rosemount type 1135F and the Foxboro type 892.

1.6.2 Rosemount Type 1135F P/I Converter

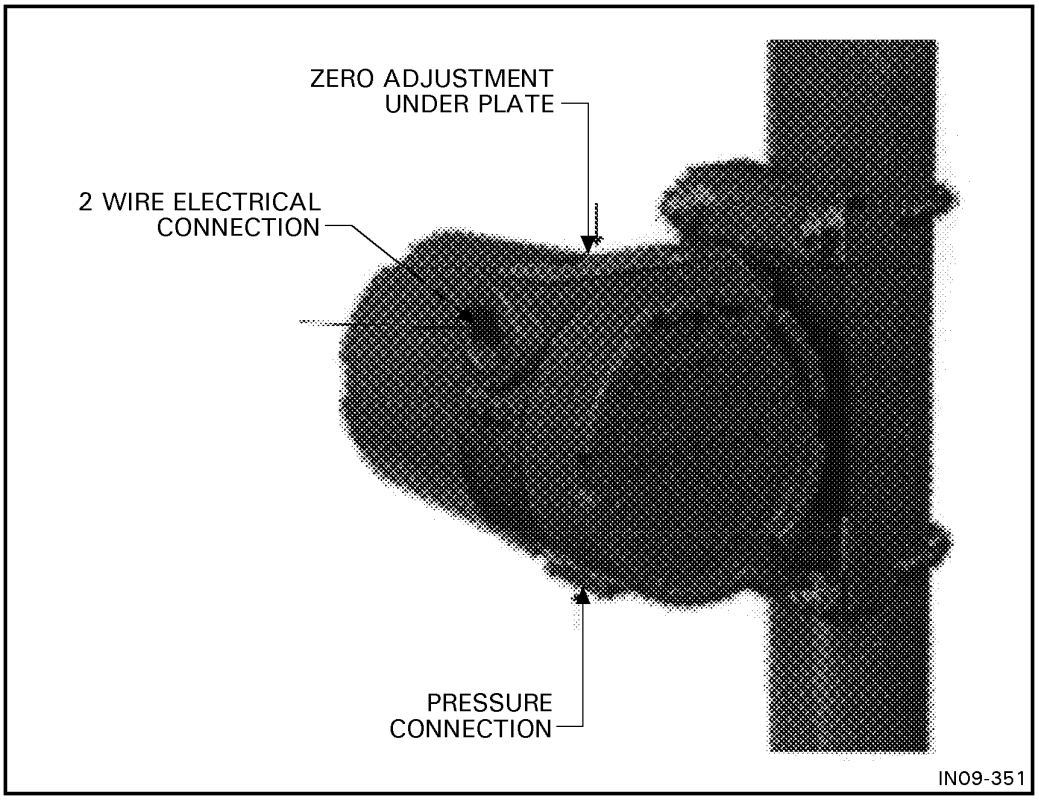
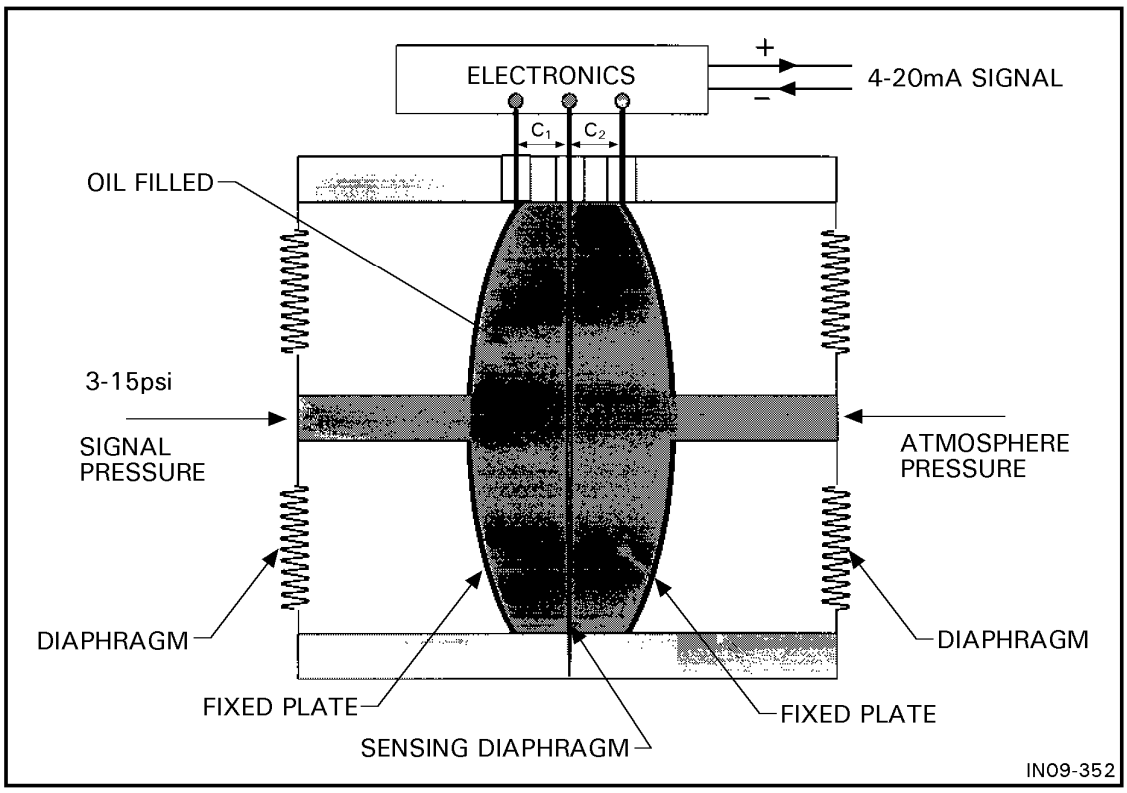


Figure 1-6 Rosemount 1135F P/I

Figure 1-6 shows a Rosemount 1135F P/I fitted to a pipe for use in the field.

OPERATION

The 1135F P/I uses a capacitive cell (the same type as the Rosemount electrical pressure transmitter). The 3-15 psi or 0.2-1 bar pneumatic signal is applied to one side of the cell. Atmospheric pressure is applied to the other side of the cell. The movement of the sensing diaphragm (maximum 0.10 mm) depends on the differential pressure across it. The difference in capacitance (C_1-C_2), as the sensing diaphragm moves, is measured by the electronics to provide the 4-20mA signal.



There is only one adjustment in the electronics. The zero adjustment. This sets the device to give 4mA output for a 3psi or 0.2 bar input. The span of the device is set in the factory to meet customer requirements.

1.6.3 The Foxboro 7010A P/I Converter

Figure 1-7 shows the basic principle of the device.

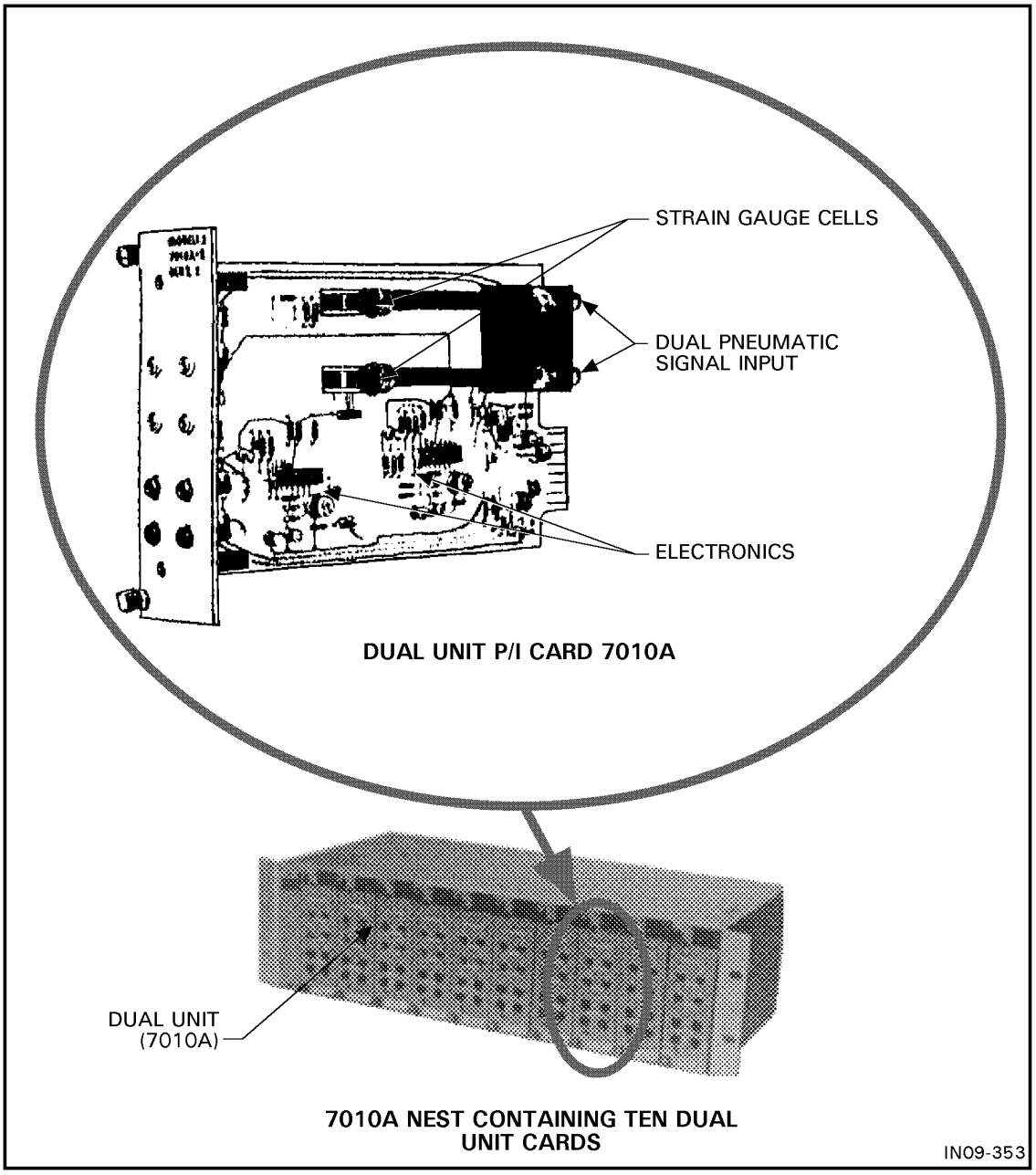
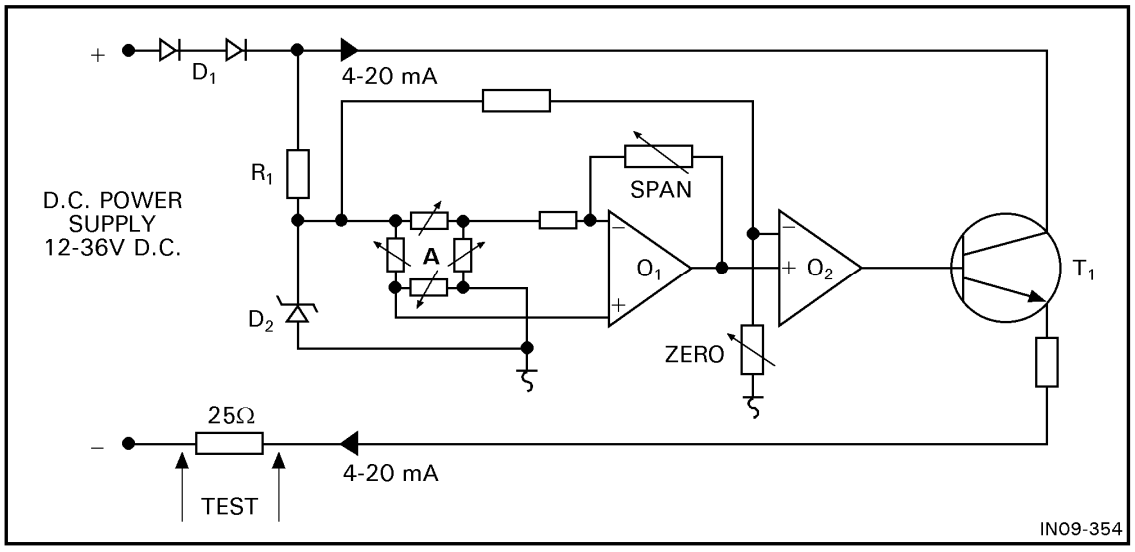


Figure 1-7 Foxboro P/I Converter 7010A

Foxboro produce a dual pneumatic to current converter for mounting in a rack instead of field mounting. The pneumatic signals are transmitted to

the control room where they can be converted to an electrical signal in a safe area. The diagram above shows the Foxboro 7010A converter together with a rack mounted 7020A nest of these converters.

This is an analog system which uses operational amplifiers. A simplified diagram of the electronics is shown below.



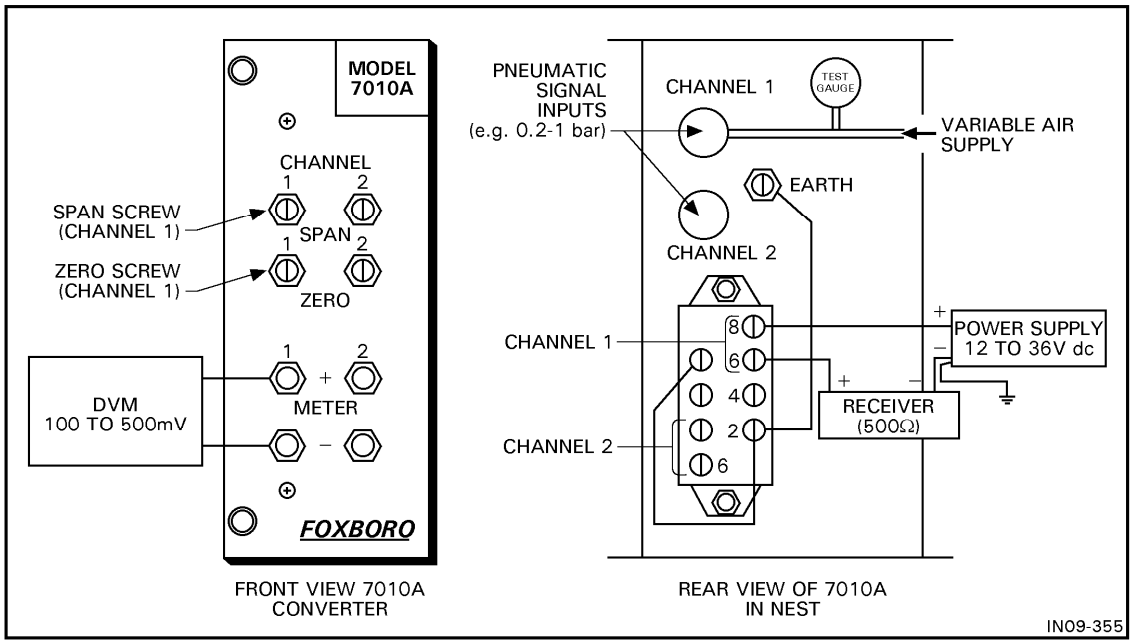
OPERATION

Component "A" is a strain gauge bridge. R_1 and D_2 provide a constant reference voltage for the bridge. The supply to the unit is from an external 24V D.C supply. Operational amplifier O_1 detects the changes in resistance (voltage) across the bridge and the pressure changes. Operational amplifier O_2 produces an output depending on the difference between O_1 output and the reference voltage. O_2 output controls the base voltage and thus the conduction of T_1. T_1 is a series transistor which varies the 4-20mA signal around the loop. D_1 is added to stop any reverse current flow if the power supply is wrongly connected. The span adjustment adjusts the gain of O_1 and the zero adjustment adjusts the reference level for O_2.

CALIBRATION

The calibration of the equipment is simple. The following section is a copy of the procedure taken from the Foxboro manual. The power supply voltage required depends on the resistance of the output load, (e.g. controller input). This is the receiver on the diagram. This is 24V dc with a 500Ω resistor put in place of the receiver.

Equipment Setup



Procedure

1) Set up the equipment as shown.
2) Adjust the air supply so that the test gauge reads 3psi or 0.2 bar.
3) Adjust the zero screw (Channel 1) so that the digital voltmeter (DVM) output is 100 mV.
4) Adjust the air supply so that the test gauge reads 15psi or 1.0 bar.
5) Adjust the zero screw (Channel 1) so that the digital voltmeter (DVM) output is 500mV.
6) Repeat steps 2 through 5 until you get the desired output.
7) Repeat steps 1 through 6 for Channel 2.

Output Load Resistance

To determine the converter's output load resistance, add the input resistance of each component in the series loop which is connected to the converter output. The total loop resistance must not exceed 1000 Ω. As an example, if the resistance is 500 Ω, as shown in the following graph, the supply voltage must be 24 V minimum.